Al-Mg-Si SERIES ALLOY PLATE EXCELLENT IN THERMAL CONDUCTIVITY AND STRENGTH, AND METHOD OF MANUFACTURING THE SAME

This is a continuation-in-part of commonly assigned co-pending application Serial No. 09/818,070, filed on March 27, 2001.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an Al-Mg-Si series alloy plate excellent in thermal conductivity and strength, and also relates to a method of manufacturing the aforementioned Al-Mg-Si series alloy plate.

Description of Related Art

Generally, Japanese Industrial Standards (hereinafter referred to as "JIS") A5052 aluminum alloy is used as high strength aluminum materials for heat exchanger parts, metallic base printed circuit boards, cutting members, etc. However, JIS A5052 aluminum alloy is inferior in thermal conductivity by 30% or more as compared with pure aluminum. On the other hand, pure aluminum having high excellent thermal conductivity is extremely low in strength and inferior to JIS A5052 aluminum alloy in cutting processability. This pure aluminum

requires removal of burrs after cutting processing, resulting in poor finished surface appearance.

Furthermore, Al-Mg-Si series alloy is also used as aluminum material of high strength in which minute Mg_2Si particles are precipitated uniformly to improve the strength. The fine Mg_2Si precipitation can be obtained by heat treatment, which improves strength and recovers toughness by hardening and annealing the alloy after cold rolling. Heating the alloy in general rolling process does not cause uniform and fine Mg_2Si precipitation, but merely causes independent precipitation of Mg and Si, resulting in insufficient strength improvement.

Thus, under the present circumstances, it is additionally required to perform heat treatment after cold rolling, resulting in an increased step, which causes an increased manufacturing cost. Furthermore, in cases where a thin plate having a thickness of 0.1 mm or the like is manufactured by heat treatment type alloy such as Al-Mg-Si series alloy, since it was common to subject the alloy plate of 1 mm thickness or less to solution treatment in a continuous annealing furnace, it was difficult to increase the cold working rate. As a result, it was difficult to obtain high strength.

Japanese Unexamined Laid-open Patent Publication No. H6-272001 discloses a method of manufacturing an Al-Mg-Si

series alloy plate in which hot rolling conditions are specified. This technique intends to restrain big and rough precipitation from being generated during hot rolling in order to perform short-time solution treatment after cold rolling, and does not intend to promote fine Mg_2Si precipitation during the rolling process.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of manufacturing aluminum alloy with outstanding thermal conductivity and strength in fewer steps.

A first method of manufacturing an Al-Mg-Si series alloy plate according to the present invention has the following structural features (1) to (10) and the second method of manufacturing an Al-Mg-Si series alloy plate has the following structural features (11) to (20).

(1) A method of manufacturing an Al-Mg-Si series alloy plate excellent in thermal conductivity and strength, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 10 mm or more but not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(2) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein Si content of the Al-Mg-Si series alloy ingot is from 0.32 to 0.60 wt%.

(3) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein Mg

content of the Al-Mg-Si series alloy ingot is from 0.35 to 0.55 wt%.

(4) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃.

(5) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the plate thickness immediately after the one of plural passes is 12 mm or less.

(6) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, and wherein the plate thickness immediately after the one of plural passes is 12 mm or less.

(7) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the rolling reduction of the cold rolling is 50% or more.

(8) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, and wherein the rolling reduction of the cold rolling is 50% or more.

(9) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the plate thickness immediately after the one of plural passes is 12 mm or less, and wherein the rolling reduction of the cold rolling is 50% or more.

(10) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (1), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, wherein the plate thickness immediately after the one of the plural passes is 12 mm or less, and wherein the rolling reduction of the cold rolling is 50% or more.

(11) A method of manufacturing an Al-Mg-Si series alloy plate excellent in thermal conductivity and strength, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less, Zn: 0.5 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 15 mm or less,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(12) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein Si content of the Al-Mg-Si series alloy ingot is from 0.32 to 0.60 wt%.

(13) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein Mg content of the Al-Mg-Si series alloy ingot is from 0.35 to 0.55 wt%.

(14) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11),

wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃.

(15) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the plate thickness immediately after the one of plural passes is 12 mm or less.

(16) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, and wherein the plate thickness immediately after the one of plural passes is 12 mm or less.

(17) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the rolling reduction of the cold rolling is 50% or more.

(18) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, and wherein the rolling reduction of the cold rolling is 50% or more.

(19) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the plate thickness immediately after the one of

plural passes is 12 mm or less, and wherein the rolling reduction of the cold rolling is 50% or more.

(20) The method of manufacturing an Al-Mg-Si series alloy plate as recited in the aforementioned Item (11), wherein the material temperature immediately before the one of plural passes is from 380 to 420 ℃, wherein the plate thickness immediately after the one of the plural passes is 12 mm or less, and wherein the rolling reduction of the cold rolling is 50% or more.

A first Al-Mg-Si series alloy plate excellent in thermal conductivity and strength according to the present invention is an alloy plate manufactured by the aforementioned method (1) to (10) and has the following structural features (21) to (24). A second Al-Mg-Si series alloy plate excellent in thermal conductivity and strength according to the present invention is an alloy plate manufactured by the aforementioned method (11) to (20) and has the following structural features (25) to (28).

(21) An Al-Mg-Si series alloy plate excellent in thermal conductivity and strength manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5

wt% or less, Cu: 0.20 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 10 mm or more but not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(22) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (21), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a heat

dissipation member, an electrically conductive member, a casing member, a light reflecting member or its supporting member.

(23) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (22), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a plasma display rear surface chassis member, a plasma display box member and a plasma display exterior member.

(24) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (22), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a liquid crystal display rear chassis member, a liquid crystal display bezel member, a liquid crystal display reflecting sheet member, a liquid crystal display reflecting sheet supporting member and a liquid crystal display box material.

(25) An Al-Mg-Si series alloy plate excellent in thermal conductivity and strength manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less, Zn: 0.5 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 15 mm or less,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(26) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (25), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a heat dissipation member, an electrically conductive member, a casing member, a light reflecting member or its supporting member.

(27) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (26), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a plasma display rear surface chassis member, a plasma display box member and a plasma display exterior member.

(28) The Al-Mg-Si series alloy plate as recited in the aforementioned Item (26), wherein the Al-Mg-Si series alloy plate is a member selected from the group consisting of a liquid crystal display rear chassis member, a liquid crystal display bezel member, a liquid crystal display reflecting sheet member, a liquid crystal display reflecting sheet supporting member and a liquid crystal display box material.

The first plasma display and liquid crystal display utilize the Al alloy plate as defined by the aforementioned Item (21) as the constitutional materials, and has the structural features as defined by the following Items (29) and (30). The second plasma display and liquid crystal display utilize the Al alloy plate as defined by the aforementioned Item (25) as the constitutional materials, and has the structural features as defined by the following Items (31) and (32).

(29) A plasma display comprising a rear chassis member, a box member and an exterior member, wherein at least one of the rear chassis member, the box member and the exterior

member is constituted by an Al-Mg-Si series alloy plate manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 10 mm or more but not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(30) A liquid crystal display comprising a rear chassis member, a bezel member, a reflecting sheet member, a reflecting plate member, a reflecting plate supporting member and a box member, wherein at least one of the rear chassis member, the bezel member, the reflecting sheet member, the reflecting plate member, the reflecting plate supporting member and the box member is constituted by an Al-Mg-Si series alloy plate manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature

immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃ /min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is 10 mm or more but not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(31) A plasma display comprising a rear chassis member, a box member and an exterior member, wherein at least one of the rear chassis member, the box member and the exterior member is constituted by an Al-Mg-Si series alloy plate manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less, Zn: 0.5 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

(32) A liquid crystal display comprising a rear chassis member, a bezel member, a reflecting sheet member, a reflecting plate member, a reflecting plate supporting member and a box member, wherein at least one of the rear chassis member, the bezel member, the reflecting sheet member, the reflecting plate member, the reflecting plate supporting member and the box member is constituted by an Al-Mg-Si series

alloy plate manufactured by a method, the method comprising the steps of:

preparing Al-Mg-Si series alloy ingot consisting essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less, Zn: 0.5 wt% or less and the balance being aluminum and inevitable impurities;

homogenizing the alloy ingot;

subjecting the alloy ingot to rough hot rolling to obtain a roughly hot rolled plate;

subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and

subjecting the finished hot rolled plate to cold rolling,

wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is not larger than 15 mm,

wherein the cold rolling is controlled such that rolling reduction is 30% or more, and

wherein the cold rolled plate is subjected to final aging at a temperature of 180 ℃ or below, or is not subjected to final aging.

Methods according to the present invention are roughly classified into two methods which are different in compositions of the Al-Mg-Si series alloy and a part of rolling conditions.

The targeted Al-Mg-Si alloy in the first method (hereinafter referred to as "first alloy") is an alloy containing Mg, Si, Fe and Cu. The targeted Al-Mg-Si alloy in the second method (hereinafter referred to as "second alloy") is an alloy containing Mg, Si, Fe, Cu and Zn.

The significance and reasons for the limitation of each element of the Al-Mg-Si alloy compositions are explained as follows.

Mg, Si, Fe and Cu are elements commonly contained in the first and second alloys.

Mg and Si are essential elements for giving strength to the alloy. If Mg content is less than 0.3 wt% and/or Si content is less than 0.2 wt%, sufficient strength cannot be obtained. On the other hand, if Mg content exceeds 0.9 wt% and/or Si content exceeds 0.8 wt%, the rolling load in the hot rolling increases, which causes a deterioration of productivity and necessitates trimming of the rolled plate

before the finish rolling because of the generated large cracks. The desirable lower limit of Mg content is 0.35 wt%, and the desirable upper limit thereof is 0.55 wt%. On the other hand, the desirable lower limit of Si content is 0.32 wt%, and the desirable upper limit thereof is 0.60 wt%.

Too much Fe and Cu causes a deterioration of corrosion resistance, resulting in an alloy plate of no practical use. Therefore, it is necessary to regulate the content of Fe and Cu such that Fe content is 0.5 wt% or less and Cu content is 0.20 wt% or less. The dpreferable Fe content is 0.25 wt% or less, and the preferable Cu content is 0.10 wt% or less.

The alloy compositions falling within the aforementioned range causes outstanding thermal conductivity equivalent to pure aluminum.

Zn is an element contained only in the second alloy. Adding a small amount of Zn such as 0.5 wt% or less does not spoil the excellent thermal conductivity, strength and electric conductivity that are important features of the alloy plate according to the present invention. Accordingly, the present invention makes it possible to reuse the Zn containing alloy which is generally difficult to use as recycling materials. This enlarges the application range of such Zn containing alloy recycling materials, which in turn contributes environmental conservations. Furthermore, too

much Zn causes a deterioration of corrosion resistance, resulting in a lacking of practicality. However, if it is controlled such that Zn content is 0.5 wt% or less, practical corrosion resistance can be assured. The preferable Zn content is 0.25 wt% or less.

In the aforementioned two methods according to the present invention, fine Mg_2Si particles can be precipitated uniformly by applying rolling under the prescribed conditions after the homogenization treatment. As a result, effects equivalent to effects obtained by solution treatment and quenching can be obtained.

The conditions of the homogenization treatment are not specifically limited. It is preferable to perform the homogenization treatment for 2 hours or more at 500 ℃ or above in accordance with a conventional method.

In the rough hot rolling, effects equivalent to effects obtained by quenching can be obtained by the temperature reduction while rough hot rolling under the predetermined temperature conditions in any one of plural passes performed at the rough hot rolling. Therefore, the material temperature immediately before the one of plural passes is required to fall within the range of from 350 to 440 ℃ which can retain the dissolved state of Mg and Si like in solution treatment. If the material temperature is below 350 ℃, Mg_2Si becomes big

and rough precipitation at this time, and thus the subsequent quenching effect cannot be obtained. Furthermore, since the material temperature is low, the rolling processability at the subsequent rough hot rolling passes deteriorates remarkably, the material temperature immediately after the one of plural passes becomes too low, resulting in a deterioration of the surface quality. On the other hand, if the material temperature exceeds 440 ℃, the material temperature will not drop enough immediately after the one of plural passes, causing insufficient quenching effects. The preferable lower limit of the material temperature immediately before the one of plural passes is 380 ℃, and the preferable upper limit is 420 ℃. Furthermore, in order to obtain the quenching effects, it is required to control such that the cooling rate during the one of plural passes is 50 ℃/min and that the material temperature immediately after the one of plurals passes falls within the range of from 250 to 340 ℃. In order to control the material temperature immediately after the one of plural passes so as to fall within the aforementioned range, forced cooling such as high-pressure shower water cooling may be performed immediately after the rough hot rolling. Furthermore, it is preferable that the rough hot rolling velocity is 50 m/min or higher.

Furthermore, in order to obtain cooling effects equivalent to quenching between the one of plural passes and the subsequent pass, it is necessary to control the plate thickness immediately after the one of plural passes. In the first alloy, it is necessary to control the plate thickness immediately after the one of plural passes so as to be not smaller than 10 mm but not larger than 15 mm. In the second alloy, it is necessary to control the plate thickness immediately after the one of plural passes so as to be not larger than 15 mm. In either case, if the thickness exceeds 15 mm, it is difficult to cool the plate to a temperature sufficient for quenching even if an additional water-cooling process is performed. The preferable plate thickness is 12 mm or less. The rolling conditions for the first alloy and those for the second alloy are different only in the aforementioned plate thickness immediately after the one of plural passes, and the other conditions are the same.

Generally, although the aforementioned rough hot rolling will be performed 10 times (passes) or more, the aforementioned rough hot rolling pass under the aforementioned conditions in order to obtain the quenching effects can be performed at any one of plural rough hot rolling passes. However, since it is required to make the plate thickness immediately after the one of plural passes 15 mm or less, the

aforementioned one of passes is usually performed at the last rough hot rolling pass or at a pass immediately before the last rough hot rolling pass. However, in cases where the aforementioned rough hot rolling is performed at any one of plural passes other than the last rough hot rolling pass, it is required to perform the rough hot rolling pass subsequent to the one of plural passes at the material temperature of from 250 to 340 ℃. If the material temperature is below 250 ℃, the load of rolling becomes larger. As a result, it becomes hard to perform the rough hot rolling because of the large load and the surface quality changes such as surface corrosion due to the reaction of aluminum and moisture.

The conditions of the final hot rolling to be performed after the rough hot rolling passes, such as the result temperature and/or the rolling velocity, are not specifically limited because solution treatment and quench treatment have been already performed by the preceding rough rolling. Accordingly, the final hot rolling can be performed depending on the plate thickness by a conventional method.

In the cold rolling, in order to obtain a predetermined strength by work hardening, it is necessary to control such that the rolling reduction is 30% or more. When the rolling reduction is 30% or more, the strength of 200 N/mm^2 or more equal to the strength of A5052 alloy (JIS(Japanese Industrial

Standards) H4000) can be obtained. A desirable rolling reduction is 50% or more.

Furthermore, if necessary, the final aging of the cold rolled alloy plate is performed at 180 ℃ or below. By performing the heat treatment at such a low temperature, the age hardening of the alloy plate will be executed to further increase the strength and the elongation. Furthermore, mechanical characteristics will also be stabilized. The preferable thermal treatment temperature is from 130 to 150 ℃.

Since the targeted Al-Mg-Si series alloy to be manufactured in accordance with the first manufacturing method according to the present invention consists essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less and the balance being aluminum and inevitable impurities, and the targeted Al-Mg-Si series alloy to be manufactured in accordance with the second manufacturing method according to the present invention consists essentially of Si: 0.2 to 0.8 wt%, Mg: 0.3 to 0.9 wt%, Fe: 0.5 wt% or less, Cu: 0.20 wt% or less, Zn: 0.5 wt% or less and the balance being aluminum and inevitable impurities, either alloy is excellent in thermal conductivity.

The method of manufacturing an Al-Mg-Si series alloy plate according to the present invention includes the steps

of: homogenizing the Al-Mg-Si series alloy ingot; subjecting the alloy to rough hot rolling to obtain a roughly hot rolled plate; subjecting the roughly hot rolled plate to finish hot rolling to obtain a finished hot rolled plate; and subjecting the finished hot rolled plate to cold rolling, wherein one of plural passes performed at the rough hot rolling is controlled such that material temperature immediately before the one of plural passes is from 350 to 440 ℃, cooling rate during the one of plural passes is 50 ℃/min or more, material temperature immediately after the one of plural passes is from 250 to 340 ℃ and plate thickness immediately after the one of plural passes is larger than 10 mm but not larger than 15 mm in the first method, not larger than 15 mm in the second method, and wherein the cold rolling is controlled such that rolling reduction is 30% or more. Accordingly, during the rough hot rolling, it is possible to obtain effects equivalent to the effects obtained by solution treatment and quench treatment. Furthermore, still higher strength can be obtained by the cold rolling at the higher rolling reduction. Therefore, without performing heat treating at another process other than rolling process, an alloy plate having high thermal conductivity and high strength can be manufactured, and a large cost reduction can be attained. Furthermore, if the cold rolled plate is further subjected to final aging at a

temperature of 180 ℃ or below, the strength and elongation can be further improved and the mechanical characteristics can be stabilized. Furthermore, since the Al-Mg-Si series alloy plate manufactured by the method explained above has good cutting processability, when cutting of this alloy plate is performed, post processing, such as deburring, become unnecessary and a cost reduction can also be attained. Furthermore, since the thermal conductivity of Al-Mg-Si series alloy is good, the alloy plate having high thermal conductivity and high strength can be manufactured by the aforementioned either method.

Furthermore, in the aforementioned two kinds of Al-Mg-Si series alloy ingot compositions, in cases where Si content is 0.32 to 0.60 wt% and/or Mg content is 0.35 to 0.55 wt%, the obtained alloy plate is excellent especially in strength.

Furthermore, in cases where the material temperature immediately before the one of plural passes is 380 to 420 ℃, sufficient quenching effects can be obtained while maintaining the rolling workability.

Furthermore, in cases where the plate thickness immediately after the one of plural passes is 12 mm or less, the plate can be fully cooled between the one of plural passes and a pass subsequent thereto. Thus, sufficient quenching effects can be obtained.

Furthermore, in cases where the rolling reduction at the cold rolling is 50% or more, the strength improvement effect due to work hardening will be remarkable.

The Al-Mg-Si series alloy plates manufactured by the aforementioned two methods according to the present invention are excellent in various characteristics mentioned above. Therefore, the alloy plates can be subjected to various forming processing. For example, the alloy plates can be preferably used as heat releasing member materials, current carrying member materials, case materials, reflecting plates or its supporting members. The aforementioned heat releasing member includes not only a member for releasing heat as its original purpose, e.g., a heat exchanger and a heat sink, but also a member required to have heat release performance other than its main purpose, e.g., a chassis or a metal base print circuit board of an electronic product such as a PDP, an LCD or a personal computer to which a built-in heat releasing or a heat releasing member is attached. As for the current carrying member, a bus bar member, various battery terminals members, capacitor terminal members for use in fuel cell vehicles or hybrid cars, terminal members of various electrical equipments and terminal members of machine appliance can be exemplified. As for the case materials, battery cases or boxes for cellular phones, PDA's, etc. and

boxes for various electric equipments can be exemplified. Since the alloy plate according to the present invention is excellent in strength and cutting processability, even a thin alloy plate can be used for a casing, and it is possible to provide a casing having sufficient strength, which is small in size and light in weight. As for the reflecting plate, a light reflecting plate for a liquid crystal beneath type backlight, a light reflecting plate for a liquid crystal edge-light type unit and a reflecting plate for an electric decorative display can be exemplified. The alloy plate may also be used as a supporting member for the aforementioned reflecting plate made of material other than aluminum. For example, a reflecting plate in which a porous resin sheet made of foamed resin composition containing inorganic filler such as olefin series polymer, barium sulfate, calcium carbonate or titanium oxide is laminated on the Al-Mg-Si series alloy plate of the present invention can be exemplified. The porous resin sheet is laminated on a supporting member by lamination processing or via an adhesive tape. Furthermore, as a material of a reflecting plate, white paint is sometimes used. In this case, a supporting member on which white paint is applied can be used as a reflecting plate. Furthermore, as a member to which heat releasing, strength and lightness are required, a keyboard substrate for use in computers,

especially note-type computers which should be extremely small in size and light in weight, a heat spreader plate and a box can be exemplified. Furthermore, it can be used as various strengthening members.

Concretely, the Al-Mg-Si series alloy plate can be used as a material for a plasma display related material such as a plasma display rear surface chassis member, a plasma display box member and a plasma display exterior member, or a liquid crystal display material such as a liquid crystal display rear chassis member, a liquid crystal display bezel member, a liquid crystal display reflecting sheet member, a liquid crystal display reflecting sheet supporting member and a liquid crystal display box material. The aforementioned plasma display rear chassis member can be also served as a heat releasing plate.

Furthermore, in a plasma display, it becomes possible to decrease the size and weight by utilizing any one of the aforementioned two kinds of Al-Mg-Si series alloy plates as an Al alloy plate constituting at least any one of rear surface chassis member, plasma display box member and plasma display exterior member. In the same way, in a liquid crystal display, it becomes possible to decrease the size and weight by utilizing any one of the aforementioned two kinds of Al-Mg-Si series alloy plates as an Al alloy plate constituting at

least any one of rear chassis member, bezel member, reflecting sheet member, reflecting sheet, reflecting sheet supporting member and box material.

EXAMPLE

Each of the alloy continuous casting slabs having compositions shown in Tables 1 and 2 was subjected to homogenization treatment of 580 ℃ x 10 hours after surface cutting, and then subjected to rough hot rolling, final hot rolling and cold rolling to obtain an alloy plate. The rolling conditions were controlled at the final rough hot rolling pass. The material temperature immediately before the final rough hot rolling pass was set to the temperature shown in each Table, the final rough hot rolling velocity was set to 80 m/min, and the thickness immediately after the final rough hot rolling pass was set as shown in each Table. The cooling rate during the pass was set as shown in each Table. Then, the material after the rough hot rolling was subjected to further finish hot rolling to be rolled into a coil. Next, the rolled material was subjected to cold rolling at the rolling reduction shown in each Table. After the cold rolling, the examples Nos. 2, 4, 11, 13, 15, 16, 22, 24, 31, 33, 35, 36 and the comparative examples Nos. 7, 9, 13 and 15 were further subjected to the final annealing under the conditions shown in each Table. As for the comparative

examples Nos. 1, 2 and 3, A1100P-H24 material, A5052P-H38 material, and A5052P-H34 material were manufactured by usual processing, respectively.

Tensile strength and thermal conductivity of each obtained alloy plate were measured, and its cutting ability was also evaluated in accordance with milling processing. The tensile strength was measured by the conventional method with JIS No.5 specimen, and the thermal conductivity was measured with a laser flash method at 25 ℃. Furthermore, the cutting processability was relatively evaluated on the basis shown below. However, as for the examples Nos. 10, 11, 30 and 31, since the final plate thickness was 0.1 mm and this kind of thin plate or foil will be usually used without being subjected to cutting process, the cutting processability were not evaluated.

○: Outstanding (no burrs)

△: Good (some burrs)

×: Poor (many burrs).

Table 1 (Corresponding to claims 1 to 10: non Zn, plate thickness: larger than 10 mm but not larger than 15 mm)

Alloy No.		Composition (wt%) Balance: Al and impurities					Hot rough rolling final pass				Cold rolling reduction rate (%)	Final aging (℃×hr)	Tensile Strength (N/mm²)	Thermal conductivity (W/mK)	Cutting processablity	Remarks
		Si	Mg	Fe	Cu	Zn	Temp. before the pass (℃)	Temp. after the pass (℃)	Thickness after the pass (mm)	Cooling rate (℃/min)						
Example	1	0.5	0.5	0.15	0.05	-	395	277	11	125	60	-	230	203	○	
	2	0.5	0.5	0.15	0.05	-	395	277	11	125	60	150x5	258	220	○	
	3	0.5	0.5	0.15	0.05	-	395	282	11	123	85	-	263	195	○	
	4	0.5	0.5	0.15	0.05	-	395	282	11	123	85	140x5	286	216	○	
	5	0.5	0.5	0.15	0.05	-	436	317	11	150	85	-	238	212	○	
	6	0.7	0.4	0.18	0.07	-	400	332	12	90	60	-	240	207	○	
	7	0.3	0.8	0.13	0.05	-	396	325	12	60	65	-	240	200	○	
	8	0.3	0.4	0.13	0.05	-	394	320	12	63	70	-	237	220	○	
	9	0.4	0.7	0.20	0.15	-	392	288	12	88	85	-	238	196	○	
	10	0.4	0.7	0.13	0.05	-	400	330	12	140	98	-	390	197	-	Product plate thickness 0.1mm
	11	0.4	0.7	0.13	0.05	-	400	330	12	140	98	130x5	395	198	-	Product plate thickness 0.1mm
	12	0.5	0.5	0.24	0.05	-	418	330	15	150	70	-	290	197	○	
	13	0.5	0.5	0.24	0.05	-	418	330	14	150	70	130x5	288	196	○	
	14	0.5	0.5	0.22	0.07	-	415	335	14	150	70	-	288	195	○	
	15	0.5	0.5	0.4	0.05	-	410	334	12	150	65	130x5	275	192	○	
	16	0.5	0.5	0.4	0.10	-	410	333	12	150	65	130x5	280	193	○	
Comparative Example	1	0.12	0.01	0.57	0.12	-	395	290	7	*1	75	-	140	218	×	A1100P-H24
	2	0.07	2.51	0.25	0.02	-	395	292	7	*1	70	-	295	138	○	A5052P-H38
	3	0.07	2.51	0.25	0.02	-	396	288	7	*1	70	-	255	142	○	A5052P-H34
	4	0.1	0.2	0.10	0.05	-	394	282	7	80	85	-	170	214	△	
	5	0.9	0.5	0.14	0.14	-	450	380	16	160	70	-	185	180	△	
	6	0.5	1.0	0.11	0.08	-	450	380	16	160	70	-	273	159	○	
	7	0.5	1.0	0.11	0.06	-	450	380	16	160	70	150x5	278	163	○	
	8	0.5	0.5	0.15	0.05	-	450	362	7	80	60	-	178	210	△	
	9	0.5	0.5	0.15	0.05	-	454	366	7	80	60	150x5	171	214	△	

*1 denotes: no forced cooling

Table 2 (Corresponding to claims 11 to 20: Zn: 0.5 or less, plate thickness: not larger than 15 mm)

Alloy No.		Composition (wt%) Balance: Al and impurities					Hot rough rolling final pass				Cold rolling reduction rate (%)	Final aging (℃×hr)	Tensile Strength (N/mm²)	Thermal conduc-tivity (W/mK)	Cutting process-ablity	Remarks
		Si	Mg	Fe	Cu	Zn	Temp. before the pass (℃)	Temp. after the pass (℃)	Thickness after the pass (mm)	Cooling rate (℃/min)						
Example	21	0.5	0.5	0.15	0.05	0.21	395	277	7	80	60	-	228	201	○	
	22	0.5	0.5	0.15	0.05	0.21	395	277	7	80	60	150x5	255	218	○	
	23	0.5	0.5	0.15	0.05	0.21	395	282	7	80	85	-	258	193	○	
	24	0.5	0.5	0.15	0.05	0.21	395	282	7	80	85	140x5	281	214	○	
	25	0.5	0.5	0.15	0.05	0.5	436	317	7	80	85	-	233	210	○	
	26	0.7	0.4	0.18	0.07	0.21	400	332	10	120	60	-	222	205	○	
	27	0.3	0.8	0.13	0.05	0.21	396	325	10	120	65	-	247	197	○	
	28	0.3	0.4	0.13	0.05	0.21	394	320	10	120	70	-	255	218	○	
	29	0.4	0.7	0.20	0.15	0.21	392	288	7	80	85	-	292	193	○	
	30	0.4	0.7	0.13	0.05	0.21	400	330	7	80	98	-	368	193	-	Product plate thickness 0.1mm
	31	0.4	0.7	0.13	0.05	0.21	400	330	7	80	98	130x5	379	197	-	Product plate thickness 0.1mm
	32	0.5	0.5	0.24	0.05	0.5	418	330	15	150	70	-	227	192	○	
	33	0.5	0.5	0.24	0.05	0.21	418	330	14	144	70	130x5	227	192	○	
	34	0.5	0.5	0.22	0.07	0.21	415	335	14	144	70	-	228	191	○	
	35	0.5	0.5	0.4	0.05	0.21	410	334	12	130	65	130x5	231	192	○	
	36	0.5	0.5	0.4	0.10	0.21	410	333	12	130	65	130x5	232	191	○	
Comparative Example	11	0.9	0.5	0.14	0.14	0.21	450	380	16	160	70	-	185	180	△	
	12	0.5	1.0	0.11	0.08	0.21	450	380	16	160	70	-	273	159	○	
	13	0.5	1.0	0.11	0.06	0.21	450	380	16	160	70	150x5	278	163	○	
	14	0.5	0.5	0.15	0.05	0.21	450	362	7	80	60	-	178	210	△	
	15	0.5	0.5	0.15	0.05	0.21	454	366	7	80	60	150x5	171	214	△	

As will be apparent from the results shown in Tables 1 and 2, it was confirmed that the aluminum alloy plate with high thermal conductivity equivalent to pure aluminum and high strength equivalent to JIS A5052 alloy can be obtained by subjecting to rough hot rolling and cold rolling under the conditions as defined by the present invention. Furthermore, the cutting ability was also good. The strength was also improved by further subjecting it to the final aging.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intent, in the use of such terms and expression, of excluding any of the equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible which fall within the scope of the presently claimed invention.